Key to Unit 4-1 Provincial Practice Questions

Part 1- Multiple Choice

1 B	21 D	41 D	61 A
2 C	22 C	42 D	62 D
3 C	23 B	43 A	63 A
4 C	24 C	44 E	64 C
5 A	25 C	45 B	65 A
6 A	26 C	46 D	66 D
7 D	27 D	47 A	67 D
8 B	28 C	48 A	68 D
9 B	29 D	49 D	69 D
10 C	30 B	50 C	70 D
11 D	31 B	51 D	71 C
12 D	32 B	52 C	72 C
13 C	33 B	53 A	73 C
14 D	34 A	54 D	74 D
15 D	35 C	55 B	75 B
16 D	36 A	56 D	76 A
17 D	37 D	57 B	77 B
18 B	38 C	58 D	78 C
19 A	39 D	59 A	
20 C	40 D	60 A	

Chemistry 12 – Provincial Practice Questions
Written Response Questions KEY

1. Consider the following amphiprotic anions reacting with each other:

$$H_2C_6H_5O_7^- + H_2PO_4^- \rightleftharpoons ?$$

A B

a) Complete the Bronsted-Lowry acid-base equilibrium for the predominant reaction. Write your answer here:

WrA SrA

$$H_2C_6H_5O_7^- + H_2PO_4^- \rightleftharpoons H_3PO_4 + HC_6H_5O_7^{2-}$$

b) Does the equilibrium above favour reactants or products? reactants

c) Explain your answer to (b). the weaker conjugate acid ($H_2C_6H_5O_7^-$) is on the reactant side.

2. Calculate the pH of a 2.5 M C_6H_5OH solution.

WA $K_a = 1.3 \times 10^{-10}$

	C_6H_5OH	+ H_2O ⇌	H_3O^+ +	$C_6H_5O^-$
[I]	2.5	X	0	0
[C]	−x		+x	+x
[E]	2.5−x		x	x

$$K_a = \frac{[H_3O^+][C_6H_5O^-]}{[C_6H_5OH]} = \frac{x^2}{(2.5-x)}$$ ← Assume $2.5 - x \cong 2.5$

$$K_a \cong \frac{x^2}{2.5}$$

$$x^2 = 2.5 K_a$$

$$[H_3O^+] = x = \sqrt{2.5(1.3\times10^{-10})}$$

$$[H_3O^+] = 1.8028\times10^{-5} M$$

→ $pH = -\log[H_3O^+]$

pH = 4.74

3. Calculate the pH of a 0.60 M $NaNO_2$ solution.

Na^+ Spec. NO_2^- WB

$K_{b\,NO_2^-} = \frac{K_w}{K_{a\,HNO_2}} = \frac{1.0\times10^{-14}}{4.6\times10^{-4}} = 2.17\times10^{-11}$

$NO_2^- + H_2O \rightleftharpoons HNO_2 + OH^-$

	NO_2^-	H_2O	HNO_2	OH^-
[I]	0.60		0	0
[C]	−x		+x	+x
[E]	0.60−x		x	x

$K_b = \frac{[HNO_2][OH^-]}{[NO_2^-]} = \frac{x^2}{(0.60-x)} \cong \frac{x^2}{0.60}$

Assume $0.60 - x \cong 0.60$

$x^2 = 0.60\,K_b$

$[OH^-] = x = \sqrt{0.60(2.17\times10^{-11})}$

$[OH^-] = 3.6116\times10^{-6}\,M$

$pOH = 5.442$

pH = 8.56

4. Calculate the pH of 0.45 M $Ra(OH)_2$. (SB)

$Ra(OH)_2 \rightarrow Ra^{2+} + 2OH^-$ (0.45 M → 2/1 → 0.90 M)

$[OH^-] = 0.90\,M$

$pOH = 0.04576$

pH = 13.95

5. Write the balanced formula equation to represent the complete neutralization reaction between aluminum hydroxide and sulphuric acid.

$2Al(OH)_3 + 3H_2SO_4 \rightarrow 6H_2O + Al_2(SO_4)_3$

6. a) Write the net ionic equation for the acid-base reaction that occurs between $KF_{(aq)}$ and $NH_4NO_{3(aq)}$. (2 marks)

$NH_4^+{}_{(aq)} + F^-_{(aq)} \rightleftharpoons NH_{3(aq)} + HF_{(aq)}$

WrA ... SrA

b) Are reactants or products favoured at equilibrium? (1 mark)

reactants are favoured.

7. A sample of pure KOH $_{(s)}$ is dissolved in water to make 8.0 L of solution and a pH = 9.82 results. Calculate the mass of pure KOH that was dissolved. (3 marks)

Plan: pH → pOH → [OH⁻] = [KOH] → mol KOH → g KOH

pH = 9.82
pOH = 14.00 − 9.82
pOH = 4.18
$[OH^-]$ = antilog(−4.18)
$[OH^-] = 6.607\times10^{-5}$ M
$[KOH] = 6.607\times10^{-5}$ M

(mol / M L)

mol KOH = 6.607×10^{-5} M × 8.0 L = 5.2855×10^{-4} mol

mass KOH = 5.2855×10^{-4} mol KOH × $\frac{56.1\ g}{1\ mol}$ = 3.0×10^{-2} g

(39.1 + 16.0 + 1.0 = 56.1)

$mass_{KOH} = 3.0\times10^{-2}$ g or 0.030 g

8. At 20°C, the pOH of a sample of water is 7.085. Calculate the value of Kw for water at 20°C using this data.

$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

In neutral water pH = pOH
pKw = pH + pOH
pKw = 2 pOH = 2(7.085)
pKw = 14.17

→ Kw = antilog(−pKw)
= antilog(−14.17)

$K_w = 6.76\times10^{-15}$

9. a) Which has a higher conductivity, 2.0 M H_2S or 0.01 M HBr? **0.01 M HBr**

Lower ion concentrations means lower conductivity

b) Justify your answer using calculations.

HBr is a SA so
$\underset{0.01M}{HBr} + H_2O \rightarrow \underset{0.01M}{H_3O^+} + \underset{0.01M}{Br^-}$
so $[H_3O^+]$ and $[Br^-]$ are both 0.01 M

H_2S is a weak acid
$H_2S + H_2O \rightleftharpoons H_3O^+ + HS^-$

H_2S	H_2O	H_3O^+	HS^-
2.0	X	0	0
−x	X	x	x
2.0 − x	X	x	x

$K_a = \frac{[H_3O^+][HS^-]}{[H_2S]} = \frac{x^2}{2.0-x}$

assume 2.0 − x ≅ 2.0

$K_a \cong \frac{x^2}{2.0}$ $x^2 = 2.0K_a \rightarrow [H_3O^+] = x = \sqrt{2.0(9.1\times10^{-8})} = 4.3\times10^{-4}$ M

so in 2.0 M H_2S $[H_3O^+]$ and $[HS^-]$ are both 4.3×10^{-4} M

10. At a particular temperature a 1.0 M HCN solution has a pH = 4.05. Calculate the value of Ka at this temperature. (4 marks) pH → $[H_3O^+]$ →(ICE) Ka

pH = 4.05

$[H_3O^+]$ = antilog (-4.05) = 8.9125×10^{-5} M

$HCN + H_2O \rightleftarrows H_3O^+ + CN^-$

	HCN	H_2O	H_3O^+	CN^-
[I]	1.0		0	0
[C]	-8.9125×10^{-5}		$+8.9125\times10^{-5}$	$+8.9125\times10^{-5}$
[E]	$1.0-8.9125\times10^{-5}$		8.9125×10^{-5}	8.9125×10^{-5}

$$Ka = \frac{[H_3O^+][CN^-]}{[HCN]} = \frac{(8.9125\times10^{-5})^2}{(1.0-8.9125\times10^{-5})} = 7.9\times10^{-9} = Ka$$

11. A 0.65 M solution of CN^- has a pH of 12.13 at a certain temperature. Calculate the Kb of CN^- at this temperature. pH → pOH → $[OH^-]$ →(ICE) Kb

pH = 12.13 pOH = 14.00 − 12.13 = 1.87

$[OH^-]$ = antilog (-1.87) = 0.01349

$CN^- + H_2O \rightleftarrows HCN + OH^-$

CN^-	H_2O	HCN	OH^-
0.65		0	0
-0.01349		+0.01349	+0.01349
0.65-0.01349		0.01349	0.01349

$$K_b = \frac{[HCN][OH^-]}{[CN^-]}$$

$$K_b = \frac{(0.01349)^2}{(0.65-0.01349)}$$

$K_b = 2.9\times10^{-4}$

12. Explain why H_3O^+ is the strongest acid possible in aqueous solution.

All stronger acids (eg. HNO_3, HCl) ionize 100% in aqueous solution to produce H_3O^+ ions (levelling effect)

13. What is the pH of a 0.70 M oxide solution?

$O^{2-} + H_2O \rightarrow 2OH^-$

0.70 M →(2/1) 1.4 M

$[OH^-]$ = 1.4 M

pOH = −log(1.4) = −0.146

pH = 14 − pOH

pH = 14.15

14. Write the equation for an amphiprotic anion acting as an acid with water.

eg) $HCO_3^- + H_2O \rightleftharpoons H_3O^+ + CO_3^{2-}$

15. How much water needs to be added to 500.0 mL of a solution of pH = 2.000 to bring the pH to 2.301.

	pH	$[H_3O^+]$
initial soln.	2.000	0.0100 M
final soln.	2.301	0.00500 M

$FC \times FV = IC \times IV$

$FV = \frac{IC \times IV}{FC} = \frac{0.0100 \times 500.0\,mL}{0.00500}$

$FV = 1000.\ mL$

Water Added = FV − IV

= 1000. mL − 500.0 mL = **500. mL**

16. A 0.60 M solution of a weak acid has a pH = 1.78. Use calculations and the table of acids to identify which acid it is. pH → $[H_3O^+]$ →(ICE) Ka

pH = 1.78 $[H_3O^+]$ = antilog (−1.78) = 0.016596 M

$HA + H_2O \rightleftharpoons H_3O^+ + A^-$

HA	H_2O	H_3O^+	A^-
0.60		0	0
− 0.016596		+0.016596	+0.016596
0.60 − 0.016596		0.016596	0.016596

$Ka = \frac{[H_3O^+][A^-]}{[HA]}$

$Ka = \frac{(0.016596)^2}{(0.60 - 0.016596)} = 4.7 \times 10^{-4}$

Close Match with HNO_2 ($Ka = 4.6 \times 10^{-4}$)

a) Write an equation to represent the predominant reaction when $HC_6H_5O_7^{2-}$ is mixed with HCO_3^-. (1 mark)

$HC_6H_5O_7^{2-} + HCO_3^- \rightleftharpoons H_2CO_3 + C_6H_5O_7^{3-}$

WrA, B, SrA, B

b) Justify your statement by comparing Ka values. (1 mark)

$Ka_{HC_6H_5O_7^{2-}} = 4.1 \times 10^{-7} > Ka_{HCO_3^-} = 5.6 \times 10^{-11}$ so $HC_6H_5O_7^{2-}$ acts as the acid reactant

c) Identify a conjugate acid-base pair. (1 mark)

$HC_6H_5O_7^{2-}$ (CA) and $C_6H_5O_7^{3-}$ (CB) or H_2CO_3 (CA) and HCO_3^- (CB)

d) Predict whether equilibrium will favour the production of reactants or products. Explain. (2 marks)

Prediction: The equil^m in a) favours Reactants

Explanation: $HC_6H_5O_7^{2-}$ (on the reactant side) is a weaker acid than H_2CO_3 (on the product side). Equilibrium always favours the weaker acid.